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THE STRUCTURE AND CLASSIFICATION OF THE PHYCOMYCETES

With a Revision of the Families and a Rearrangement of the North American Genera

By CHARLES E. BESSEY

WITH ONE PLATE

The phycomycetes include nine families of fungi (six, to ten, twelve, or even nineteen according to different authors) which have been brought together very largely on account of their evident relationship to the filamentous algae. These families, as here limited, are the Synchytriaceae, Chytridiaceae, Saprolegniaceae, Cladochytriaceae, Ancylistaceae, Peronosporaceae, Mucoraceae, Entomophthoraceae, and Monoblepharidaceae. They differ very much in the structure of the plant body, and it is difficult to see on what grounds they can be regarded as constituting a single group. Some are rounded cells, which live parasitically in the tissues of higher plants; others are globular coenocytes with parasitic rhizoids; others are branching, non-septate, coenocytic filaments; while still others are septated filaments consisting of ordinary uninucleated cells. Yet in the latest scheme of classification, which is found in the third edition of Engler's " Syllabus der Pflanzenfamilien " (1903) the phycomycetes are treated as a natural class of the true fungi (Eumycetes).

In some recent work on the lower plants it has been necessary for me to examine these and other related forms with some care, and as a result I have been able, as I think, to show that they do not constitute a single group, but that on the contrary they have arisen through the fungal modification of several algal types. Thus I regard the Synchytriaceae as having originated from or near the Protococcaceae in the order Protococcoideae by the adoption of the parasitic habit. In like manner the Chytridiaceae originated from or near the Botrydiaceae in the order Siphoneae, and the Saprolegniaceae from or near the Vaucheriaceae in the same order of algae. It seems probable that the Cladochytriaceae, Ancylistaceae, Peronosporaceae, Mucoraceae, and Entomophthoraceae are mere modifications of the Saprolegniaceae, due to increasing hysterophytism. The Monoblepharidaceae, on the other hand, probably came from quite a different algal phylum,—the Confervoideae,—and their morphological characters suggest a close affinity with the Oedogoniaceae.

The mutual relationships of these families, and their relationships to the algae are shown in a general way in the accompanying plate, where the orders are printed in vertical lines, and the families in horizontal, the fungi being distinguished by being underlined.

It will be seen that the phycomycetes are distributed among three orders, *viz.*, Protococcoideae, Confervoideae, and Siphoneae, all of the class Chlorophyceae, of the branch Phycophyta. It follows that in any treatment of these fungi their affinities with their algal relatives, rather than their mutual relationships, must dominate their classification. It is no more possible to treat them as a single monophyletic group, without doing violence to Nature, than it is to treat the lichens as a single group, or the parasites among the flowering plants.

The branch Phycophyta includes two classes, Chlorophyceae and Phaeophyceae, the latter constituting a side line which ends abruptly with the higher brown seaweeds,—the Laminariaceae and the Fucaceae. The class Chlorophyceae, on the contrary, has not only been fertile in variations within the class, but from it have been evolved the higher groups of plants. The order Protococcoideae must be regarded as representing the primitive type of the Phycophyta, and from this came the principal phylum now represented by the order Confervoideae. From the latter it is easy to derive the simpler Carpophyta as represented by the Coleochaeteae, and thence the steps are not difficult to trace to the other classes of the carpophytes (Rhodophyceae, Charophyceae, Ascomyceteae, and Basidiomyceteae), and the lower Bryophyta. The order Confervoideae is thus to be regarded as the principal phylum leading up to the higher groups of the vegetable kingdom. It has given rise, also, to two lateral phyla, represented by the orders Conjugatae and Siphoneae. The origin of the Conjugatae as a result of increasing sluggishness of Ulotrichaceae has been sufficiently discussed elsewhere.[1] By a decreasing septation of the filament, the Ulotrichaceae gave rise to the Cladophoraceae, and from the latter the passage is not difficult to the simpler Siphoneae, and thence to the more complex marine forms, and along another line which passes through or near the Vaucheriaceae to a group of half a dozen families of fungi. It is possible also that from the vicinity of the Ulotrichaceae a genetic line originated from which the Phaeophyceae were derived.

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[1] "The Structure and Classification of the Conjugatae," in *Transactions of the American Microscopical Society,* Vol. XXIII, pp. 145–147.

BRANCH II—**PHYCOPHYTA**

Phycophytea, Spore Tangles

Single cells, threads, or masses, the latter forming a branching plant with rhizoids; reproducing asexually (propagation) by fission, and sexually (generation) by the union of two protoplasts (gametes) to form a single spore (zygote) which is often a resting-spore. Plants from microscopic to large, sometimes a hundred metres or more in length, mostly aquatic, normally containing chlorophyll in chromatophores, but this often obscured by a yellowish or a brownish coloring matter (phycoxanthin and phycophaein), exceptionally without chlorophyll (as in the hysterophytes).

KEY TO THE CLASSES.

A. Mostly one-celled or filamentous (rarely stratose or tabular) plants, mostly chlorophyll-green, or yellowish (colorless in hysterophytes), *Chlorophyceae.*

B. Mostly massive or filamentous (very rarely one-celled) plants, brown or olive-green (no hysterophytes in this class), *Phaeophyceae.*

CLASS **CHLOROPHYCEAE**

Green Algae

Plant-body from microscopic single cells to large multinucleate, non-septate, branching coenocytes, or threads of cells, simple or branched, or rarely plates or tubes of cells; cells containing chlorophyll (excepting in hysterophytes) and thus bright green but this sometimes obscured by phycoxanthin and then yellowish or brownish; asexual reproduction (propagation) by fission of the whole plant or some of its parts, or by zoospores; sexual reproduction (generation) by the formation of a zygote (usually within the parent plant) as the result of the union of equal, undifferentiated gametes (isogametes), or of unequal male and female gametes (heterogametes, *i. e.,* androgametes and gynogametes), which are motile zoospores (planogametes) or motionless protoplasts (aplanogametes), as follows: (I) isogamy, (1) both planogametes, (2) both aplanogametes; (II) heterogamy, (3) androgametes and gynogametes motile, (4) androgametes (now called antherozoids) motile, gynogametes (now called oospheres or eggs) motionless. Typically fresh-water plants (" fresh-water algae "), but with many marine species also. Their zoospores and antherozoids usually have two terminal cilia, sometimes four, or a crown, rarely they are ciliated throughout. The hysterophytes are parasitic or saprophytic, and colorless, and show more or less morphological degradation. (Species, 7,000 to 8,000.)

KEY TO THE ORDERS.

A. Plants all unicellular; generation planogametic, *Protococcoideae.*

B. Plants filamentous or stratose; generation from planogametic isogamy to gynogametic heterogamy, *Confervoideae.*

C. Plants filamentous (or unicellular by solution); generation aplanogametic, *Conjugatae.*

D. Plants tubular or spheroidal coenocytic; generation from planogametic isogamy to gynogametic heterogamy, *Siphoneae.*

Order PROTOCOCCOIDEAE

Green Slimes

Plants microscopic, unicellular, but sometimes aggregated into definite and regular colonies, green (except in the hysterophytes), with mostly parietal chromatophores, occasionally concealed in old plants by a red pigment; propagation by cell-division and zoospores, and the formation of agamic, thick-walled resting spores (chlamydospores); generation isogametic, or heterogametic, resulting in the formation of a single zygote. In many species the vegetative cells, or even the zoospores (after losing their cilia) divide repeatedly within a gelatinous mass, and then constitute the " Palmella stage," formerly supposed to be distinct genera, *e. g., Palmella, Gloeocystis,* etc. Many cells of Protococcoideae contain one or more contractile vacuoles.

KEY TO THE FAMILIES.

A. Vegetative cells not ciliated,

I. Cells single, or in loose irregular colonies, or in gelatinous masses,

a. Cells containing chlorophyll,
1. Not forming zoospores, *Pleurococcaceae.*
2. Forming zoospores, *Protococcaceae.*
b. Cells without chlorophyll, *Synchytriaceae.*
II. Cells aggregated into regular colonies, *Hydrodictyaceae.*
B. Vegetative cells ciliated, *Volvocaceae.*

But one of the foregoing families, the Synchytriaceae, is composed of fungi, and accordingly the others will not be noticed further at this time.

Family SYNCHYTRIACEAE

Vegetative cells mostly spherical or ellipsoidal, not ciliated, without chlorophyll, growing solitary or merely approximated in the cells of aquatic or terrestrial plants, each eventually becoming a zoosporangium, or dividing into several to many zoosporangia; propagation by zoospores, and the formation of agamic resting spores; generation by the union of two equal, free-swimming, uniciliate gametes (known for but one genus).

KEY TO THE GENERA.
A. Each vegetative cell becoming a single zoosporangium, or resting spore,
I. Zoospores with two cilia, 1. *Olpidiopsis.*
II. Zoospores with one cilium,
a. Zoosporangia free within the host cell (at least not grown fast to its wall),
1. Resting spore formed by union of two planogametes, 2. *Reessia.*
2. Resting spores agamic, 3. *Olpidium.*
b. Zoosporangial wall grown fast to that of the host cell, 4. *Pleolpidium.*
B. Each vegetative cell dividing into several to many zoosporangia, or one to many resting spores,
I. Zoospores with two cilia,
a. Zoosporangia completely filling the host cell, 5. *Rozella.*
b. Zoosporangia only partly filling the host cell, 6. *Woronina.*
II. Zoospores with one cilium,
a. Zoosporangia formed directly from the vegetative cell, 7. *Synchytrium.*
b. Zoosporangia formed by the protoplasm after it has escaped from the vegetative cell, 8. *Pycnochytrium.*

1. *Olpidiopsis* Cornu. Zoosporangium smooth, globose, ellipsoid, or fusiform, emptying by a tube; zoospores ellipsoid, biciliate; rest-

ing spores globose or ellipsoid, thick-walled, and roughened or spinose.—Minute parasites in the cells of water moulds (Saprolegniaceae) and pond scums (Zygnemataceae). Resting spores 60 to 70 μ in diameter.

2. *Reessia* Fischer. Zoosporangium smooth, thin-walled, almost completely filling the host cell, emptying by a short or long tube; zoospores few, very large, uniciliate, rarely developing directly into new plants, usually acting as gametes and uniting to form a biciliate, free-swimming body, which penetrates a host cell and there forms a thick-walled zygote; the latter eventually dividing internally into smaller zoospores which, escaping by a tube, penetrate other host cells, and later form zoosporangia.—Minute parasites (two species) in the cells of *Lemna* and *Cladophora*. The cells for several days after entering their hosts show amoeboid movements.

3. *Olpidium* A. Braun. Zoosporangium smooth, globose, emptying by a tube; zoospores globose or oblong, with a single cilium; resting spores globose, thick-walled, smooth, arising by the formation of a thick wall about the vegetative cells.—Minute parasites in the cells of marine and fresh-water algae, fungi, flowering plants, pollen, spores, and rotifers. Zoosporangia 15 to 70 μ in diameter; resting spores 16 to 40μ.

4. *Pleolpidium* Fischer. Vegetative cells at first small with a distinct wall, soon entirely filling, and its own wall growing fast to the wall of the host cell, then producing numerous uniciliate zoospores which escape through a short tube; resting spores occupying only a part of the host cell, thick-walled, finely spinose.—Minute parasites (few species) in various water fungi (Saprolegniaceae and Monoblepharidaceae).

5. *Rozella* Cornu. Vegetative cell occupying the whole width of the host cell from whose protoplasm it is indistinguishable; zoosporangia arising through the successive formation of cross septa, hence arranged in a single row, each emptying by a very short tube; zoospores reniform, laterally biciliate; resting spores formed by the division of the vegetative cell into several cells which then round up and secrete a thick, spinose wall.—Minute parasites (two species) in water moulds (Saprolegniaceae). Zoospores 6 to 8 by 4μ; resting spores 20 μ in diameter.

6. *Woronina* Cornu. Vegetative cell through the successive formation of cross septa by the host becoming a row of cells occupying

the whole width of the host filament; each one of these cells may divide into numerous spherical or flattened zoosporangia, which but partly fill the host cell; zoospores biciliate, escaping through a short tube; resting spores arising by the rounding up and division of the protoplasm of a cell and the formation of one or more spherical masses of resting spores, which on germination divide internally to form zoospores.—Minute parasites in water moulds (*Saprolegnia*) and green felt (*Vaucheria*), and rotifers. Zoosporangia 14 to 30μ; zoospores 2 to 4μ by 4 to 5μ; resting spores 4 to 5μ.

7. *Synchytrium* DeBary. Vegetative cell large, spherical, thin-walled, often yellow or orange-red, later dividing internally into many, smooth, closely packed, and angular zoosporangia; zoospores globose, uniciliate, escaping through short-necked openings; resting spores arising by the formation of a thick wall about a vegetative cell, sometimes several, by the division of the cell.—Microscopic parasites (many species) in the epidermal cells of higher plants, often producing colored galls. Zoosporangia 24 to 60μ; zoospores 2 to 3μ; resting spores 30 to 150μ.

8. *Pycnochytrium* DeBary. Vegetative cell at maturity provided with a firm wall, its protoplasm escaping through a small opening, and secreting a new wall (within the same host cell), then dividing internally into numerous, spherical or angular zoosporangia; zoospores spherical to elongated, uniciliate, escaping through short, papillary openings; resting spore arising by the formation of a thick, brown wall about a vegetative cell, sometimes several, from the division of the cell.—Microscopic parasites (of several species) in the epidermal cells of higher plants, forming small galls. Zoosporangia 20 to 25μ; resting spores 40 to 280 μ in diameter.

Order CONFERVOIDEAE

The Confervas

Plants filamentous or stratose, sometimes imperfectly septate, the segments being multinucleate, and therefore coenocytes, green, with definite ovoid or lamelliform chromatophores (except in hysterophytes); propagation by the fracture of the filaments, or the formation of zoospores; generation by the union of two planogametes (isogametes or heterogametes), or of eggs (gynogametes) and antherozoids (androgametes).—Mostly fresh-water algae, floating on ponds and in running waters. The principal families, but one of which is hysterophytic, are indicated below.

Key to the Families.

A. Plants stratose, cells in one or two layers, *Ulvaceae.*
B. Plants filamentous,
I. Generation isogamic,
a. Plants with true cells (uninucleate),
1. Elongated filiform, mostly simple, *Confervaceae.*
2. Minute, short filiform, branched, *Chroolepidiaceae.*
b. Plants with coenocytic segments (multinucleate),
1. Rhizoids lateral, small or wanting, *Cladophoraceae.*
2. Rhizoids terminal, large, *Pithophoraceae.*
II. Generation heterogamic,
a. Both gametes biciliated, motile,
1. Several eggs in each oogonium, *Sphaeropleaceae.*
2. One egg in each oogonium, *Cylindrocapsaceae.*
b. Only the antherozoids ciliated,
1. Plants green (holophytes), *Oedogoniaceae.*
2. Plants colorless (hysterophytes), *Monoblepharidaceae.*

Family MONOBLEPHARIDACEAE

Plants filamentous, tubular below, septate above, branching, colorless; propagation by uniciliated swarmspores (zoospores); generation by the union of uniciliated antherozoids with large eggs produced singly in terminal or intercalary oogonia; antherids usually near the oogones, subterminal.—Small saprophytic fungi found in water on decaying plants and animals. But one genus is known.

1. *Monoblepharis* Cornu. Vegetative filaments cylindrical, of uniform diameter, branched; swarmspores with one (posterior) cilium; oogone enlarged, spherical or clavate, terminal or intercalary; antheridia cylindrical, usually just beneath the oogones.—Two species, on dead plants and animals in water.

Order CONJUGATAE

Pond Scums

This order is characterized in the place referred to earlier in this paper. Although some of the phycomycetes (Mucoraceae and Entomophthoraceae) have been hitherto referred to this order, it is much more likely that they belong to the Siphoneae, and accordingly they are here so disposed.

Order SIPHONEAE

Plants saccate or tubular, often much branched, non-septate or partially septate, multinucleate and therefore coenocytic, the filaments sometimes aggregated into plants of definite form, green (except in hysterophytes) with discoid, parietal chromatophores; propagation by (1) the internal division of the protoplasm of a part (sporangium), or the whole of the plant into spores,—in water into zoospores,—in the air into walled spores; (2) the contraction of definite masses of protoplasm into agamic resting spores (aplanospores or chlamydospores); generation by the union of (1) ciliated isogametes, (2) ciliated heterogametes, (3) antherozoids with non-ciliated gynogametes, (4) antherid nuclei (non-ciliated) with non-ciliated gynogametes, in all cases producing zygotes.—Fresh-water and marine algae, and many filamentous fungi (hysterophytes), including many families. Only the more important algae (from the standpoint of this paper) will be noticed.

KEY TO THE FAMILIES.

A. Generation, where known, isogamic,
  I. Plants small to large, branched, septate, very rarely non-septate (holophytes), *Valoniaceae.*
  II. Plants minute, clavate, pyriform, or spherical, terminating below in a simple or branched rhizoid, non-septate,
    a. Plants green (holophytes), *Botrydiaceae.*
    b. Plants colorless (hysterophytes), *Chytridiaceae.*
B. Generation, where known, typically heterogamic,
  I. Plants consisting of long, branching, non-septate filaments (in some hysterophytes very much reduced),
    a. Chlorophyll-bearing (holophytes), *Vaucheriaceae.*
    b. Without chlorophyll (hysterophytes),
      1. Aquatic, parasitic and saprophytic on aquatic plants and animals,
        a. Plants consisting of well-developed free filaments and endogenous rhizoids, *Saprolegniaceae.*
        b. Plants consisting of endogenous filaments, no rhizoids,
          1. Filaments branched, *Cladochytriaceae.*
          2. Filaments simple, sometimes reduced to one or two cells, *Ancylistaceae.*
      2. Not aquatic,
        a. Parasitic in the tissues of higher plants (rarely aquatic, and parasitic or saprophytic), *Peronosporaceae.*

b. Saprophytic on various substances or parasitic on other fungi (rarely aquatic), *Mucoraceae.*
c. Parasitic in the bodies of insects (rarely in plants, still more rarely saprophytic), *Entomophthoraceae.*

Family CHYTRIDIACEAE

Plants minute, saccate, spherical to elongated, parasitic or saprophytic, colorless, with a simple or branching rhizoid below, the latter penetrating the host; propagation (1) by the division of the protoplasm of the plant body into spherical, uniciliate zoospores, which escape through special openings, or (2) by the transformation of the protoplasm into an agamic resting spore, or (3) by the formation of resting spores in the rhizoids; generation unknown (or of doubtful occurrence in *Polyphagus*).

KEY TO THE GENERA.

A. Zoospores escaping through simple or tubular openings, rhizoids fine, usually branched,
  I. No rhizoidal enlargement below the plant body,
    a. Plant-body epiphytic, 1. *Rhizophidium.*
    b. Plant-body endophytic, 2. *Entophlyctis.*
  II. With rhizoidal enlargements below the plant-body spherical or elongated, endophytic or epiphytic,
    a. Parasitic, epiphytic, 3. *Phlyctochytrium.*
    b. Saprophytic, only the rhizoids imbedded in the nourishing stratum, 4. *Rhizidium.*
B. Zoospores escaping through an opening provided with a removable cap; rhizoids mostly simple, 5. *Chytridium.*
Anomalous Genus.—Plant with many rhizoids, the slender ramuli penetrating several hosts, 6. *Polyphagus.*

1. *Rhizophidium* Schenk. Plant epiphytic, mostly spherical (or somewhat elongated), its simple or branching rhizoid penetrating the host; zoospores formed in the unmodified plant body, posteriorly uniciliate, escaping singly by a simple or tubular opening; resting spores thick-walled, formed by the direct transformation of the protoplasm of the plant-body.—Species many, parasitic on fresh-water algae, water moulds, minute aquatic animals, pollen cells, etc. Plants 15 to 50μ; zoospores 2 to 3μ.

2. *Entophlyctis* A. Fischer. Plant endophytic, spherical to pyriform, with the branching rhizoids arising basally, or at several points; zoospores posteriorly uniciliate, escaping through a tube of

varying length; resting spores thick-walled, formed by the direct transformation of the protoplasm of the plant-body.—Species several, in fresh-water algae. Plants 5 to 25μ; zoospores 3 to 5 μ.

3. *Phlyctochytrium* Schroeter. Plant epiphytic, spherical, ellipsoidal, or pyriform, the rhizoidal enlargements spherical, single or several, endophytic or epiphytic, with branched rhizoids; zoospores escaping singly through the usually terminal opening; resting spores thick-walled, formed by the direct transformation of the protoplasm of the plant-body.—Species several, on fresh-water algae and minute aquatic animals. Plant-body 10 to 30μ by 30 to 35μ; zoospores 2 to 4μ.

4. *Rhizidium* A. Braun. Plant saprophytic, spherical or ellipsoidal, with an elongated rhizoidal enlargement bearing branched rhizoids which are imbedded in the nourishing stratum; zoospores posteriorly uniciliate, escaping in a mass of slime; resting spores thick-walled and hairy, formed by the direct transformation of the protoplasm of the plant-body; in germination the protoplasm escapes through a terminal opening in a mass which remains attached to the empty wall and divides internally into zoospores.—The single species is saprophytic in the slime of fresh-water algae. Plant-body 40 to 80μ by 25 to 40μ; zoospores 5μ; resting spores 15 to 30μ.

5. *Chytridium* A. Braun. Plant epiphytic, spherical or ellipsoidal, with a short tubular rhizoid (which rarely may have fine lateral branches) penetrating the host cell; zoospores escaping by the falling away of a circular cap; resting spores formed within the rhizoid, soon becoming as large as the plant-body, thick-walled, in germination producing a tube which enlarges terminally and produces zoospores.—Species several, on green and red algae. Plant-body 15 to 60μ by 15 to 30μ; zoospores 25 to 40μ.

Here may be placed provisionally the genus *Polyphagus* which is unquestionably related to the foregoing genera, from which in fact it differs only in its peculiar generation, regarding which we may quite properly question whether it is not after all a case of cannibalism, followed by the formation of agamic resting spores in the rhizoids, as in *Chytridium.*

6. *Polyphagus* Nowakowski. Plant free, spherical or ellipsoidal, with numerous rhizoids arising at different points, much branched, the ultimate ramuli much attenuated and penetrating the separate hosts; zoospores ellipsoidal, uniciliate, formed by the escape of the

plant protoplasm into a cylindrical thin-walled sac, and its subsequent internal division; generation (?) by the contact of a rhizoid of one plant with the body of the other, the result being the transfer of the contents of the latter into a swelling in the former, and the formation of a thick-walled, oval or irregular resting spore (zygote?).—Species one, parasitic on *Euglena,* one plant often penetrating several hosts with its slender ramuli. Plant about 37μ; resting spore 20 to 30μ.

Family SAPROLEGNIACEAE

Water Moulds

Plants minute, aquatic, without chlorophyll, parasitic or saprophytic on animals and plants, consisting of mostly branching, non-septate (or sparingly septate) filaments, attached by branching rhizoids which penetrate their hosts; propagation (1) by the formation of numerous, mostly biciliate, zoospores in the ends of branches set off by cross-walls, or by the formation of aplanospores, (2) by the formation of single spherical conidia ("chlamydospores"); generation by the formation of one or more eggs in each more or less spherical oogone, which are fertilized by the transfusion of the protoplasm of the clavate antherid (usually originating near by) through slender fertilizing tubes which penetrate the oogone wall. (Occasionally the eggs develop without fertilization.)

There are two sub-families (considered to be families by some authors).

I. Filaments not constricted, *Saprolegnieae.*
II. Filaments constricted, *Leptomitaceae.*

Sub-family SAPROLEGNIEAE

Vegetative filaments of uniform diameter, not constricted; zoosporangia cylindrical to ovoid; oogones with one or more eggs.

KEY TO THE GENERA.

A. Zoospores biciliate,
- I. In several rows in the zoosporangia,
  - a. Escaping from the zoosporangium by a single terminal opening,
    - 1. Dispersing upon escaping from the zoosporangium,
      - *a.* Zoosporangia ovoid, 1. *Pythiopsis.*
      - *b.* Zoosporangia cylindrical, 2. *Saprolegnia.*

2. Encysting about the mouth of the zoosporangium, 3. *Achlya.*
b. Escaping singly by individual openings, 4. *Dictyuchus.*
II. In one row in the zoosporangia, 5. *Aphanomyces.*
B. Zoorspores multiciliate, 6. *Myrioblepharis.*

1. *Pythiopsis* DeBary. Vegetative filaments slender; zoosporangia terminal, ovoid, the later ones forming laterally below (not within) the older ones; zoospores originating in several rows in the zoosporangium, ovoid, terminally biciliate, germinating directly after coming to rest; oogones terminal, each containing one, rarely two or three eggs.—Species one, on dead animal and vegetable matter.

2. *Saprolegnia* Nees. Vegetative filaments stout, unbranched, or paniculately branched; zoosporangia terminal, cylindrical, the later growing through the empty older ones; zoospores originating in several rows in the zoosporangia, ovoid, terminally biciliate, encysting soon after dispersing, later escaping again as reniform, laterally biciliate zoospores which germinate upon coming to rest; oogones mostly terminal, rarely intercalary, each with one or more, commonly many, eggs.—Species many, on dead, rarely on living, animals.

3. *Achyla* Nees. Vegetative filaments stout, mostly branched; zoosporangia terminal, cylindrical or clavate, the later ones forming laterally below (not within) the older ones; zoospores originating in several rows in the zoosporangia, ovoid, terminally biciliate, encysting immediately, without dispersing, at the mouth of the zoosporangium, later escaping as reniform, biciliate zoospores which germinate upon coming to rest; oogones terminal, rarely intercalary, each with one or two, commonly many, eggs.—Species many, on decaying vegetable or animal matter, rarely on living animals.

4. *Dictyuchus* Leitgeb. Vegetative filaments of medium thickness, somewhat branched; zoosporangia terminal, cylindrical or clavate, the later ones forming laterally below the older ones; zoospores originating in several rows in the zoosporangium, and there encysting, becoming polyhedral by mutual pressure, later escaping through lateral openings (one for each zoospore), reniform, laterally biciliate, germinating upon coming to rest; oogones terminal or intercalary, each with one or many eggs.—Species three, on decaying animal or vegetable matter.

5. *Aphanomyces* DeBary. Vegetative filaments very slender, little branched; zoosporangia terminal, narrowly cylindrical; zoospores

formed in a single row in the zoosporangium, fusiform, encysting in a cluster about the mouth of the zoosporangium, later escaping as reniform, laterally biciliate zoospores, and germinating upon coming to rest; oogones terminal or intercalary, each with one egg.—Species few, on decaying animal matter, and living or dead plants.

6. *Myrioblepharis* Thaxter. Vegetative filaments slender, little branched; zoosporangia ovoid to spherical, terminal, the later formed within the older ones, the contents escaping as a single, multiciliate mass, which later divides into usually four oval or oblong multiciliate zoospores; generation unknown.—The place of this singular genus is problematical, and its position here is merely provisional. Its single species occurs on submerged sticks.

Sub-family LEPTOMITACEAE

Vegetative filaments divided by constrictions into segments, often much enlarged below; zoosporangia cylindrical, pyriform, or ellipsoid; resting conidia often present; oogones with but one egg.

KEY TO THE GENERA.

- A. Plant body of segments similar in size and form,
  - I. Zoospores biciliate,
    - a. Zoosporangia cylindrical, 7. *Leptomitus.*
    - b. Zoosporangia spherical or ovoid, 8. *Apodachlya.*
  - II. Zoospores uniciliate, 9. *Gonapodya.*
- B. Plant body composed of an enlarged basal segment, bearing smaller terminal branches,
  - I. Constrictions in all parts of the plant body,
    - a. Zoosporangia of one kind,
      - 1. Basal segment of plant body similar in form to the branches, 10. *Sapromyces.*
      - 2. Basal segment of plant body of much different form from the branches 11. *Rhipidium.*
    - b. Zoosporangia of two kinds, smooth-cylindrical, and ovoid-prickly, 12. *Araiospora.*
  - II. Constrictions only at the base of the zoosporangia and conidia, 13. *Blastocladia.*

7. *Leptomitus* Agardh. Vegetative filaments slender, somewhat stouter below, branched, the segments long-cylindrical; zoosporangia cylindrical, terminal, the later ones formed directly below the earlier; zoospores ovoid, terminally biciliate, dispersing immediately upon escaping; generation unknown.—One species, in water containing organic matter.

8. *Apodachlya* Pringsheim. Vegetative filaments slender, simple or sparingly branched, segments cylindrical; zoosporangia broadly oval or pyriform, terminal, or apparently lateral by the branching of the filament; zoospores encysting at the mouth of the zoosporangium, later escaping as reniform, laterally biciliate zoospores, which germinate upon coming to rest; generation unknown.—Two species, on decaying algae.

9. *Gonapodya* Fischer. Vegetative filaments moniliform, much branched, the segments short-ellipsoidal to cylindrical; zoosporangia long-oval, terminal, the later forming within the older, empty ones; zoospores oval or elliptical, very variable in size, uniciliate, dispersing immediately upon escaping; generation unknown.—Two species, on decaying plants in water.

10. *Sapromyces* Fritsch. Vegetative filaments with a slightly enlarged basal segment, umbellately branched above, the segments similar to but smaller than the basal segment; zoosporangia subcylindrical or nearly oval, terminal or lateral; zoospores discharged in a mass, at first surrounded by a thin membrane, soon escaping as reniform laterally biciliate zoospores; oogones terminal, or lateral in whorls, pyriform.—Two species, on decaying vegetable matter.

11. *Rhipidium* Cornu. Vegetative filaments with a very large basal segment, swollen above, often lobed or branched, bearing many slender branches; zoosporangia terminal or lateral on the slender branches, broadly oval; zoospores discharged in a mass, at first surrounded by a thin membrane, soon escaping as reniform, laterally biciliate zoospores; oogones terminal, spherical.—Species few, on decaying vegetable matter.

12. *Araiospora* Thaxter. Vegetative filaments with a much enlarged, cylindrical, basal segment, from whose summit arise smaller, umbellately divided branches of similar segments; zoosporangia terminal or lateral, in whorls of two kinds, (1) smooth, broadly cylindrical, or elliptical, (2) spinose, ovoid or pyriform; zoospores discharged in a mass, at first surrounded by a delicate membrane, soon escaping as reniform, laterally biciliate zoospores; oogones in whorls or umbels, spherical.—Two species, on decaying vegetable matter.

13. *Blastocladia* Reinsch. Vegetative filaments with an enlarged cylindrical basal portion (stem) which is much branched above, the branches rather stout, constrictions only immediately below the zoo-

sporangia; zoosporangia terminal or lateral, cylindrical to broadly oval; zoospores oval or elliptical, terminally biciliate, dispersing upon escaping from the zoosporangium; resting conidia terminal or sub-terminal, bluntly ovoid; generation unknown.—Two species, on decaying vegetable matter.

Family CLADOCHYTRIACEAE

Plant a reduced, slender, parasitic or saprophytic, much-branched, non-septate filament, developing terminal and intercalary enlargements, which become (1) zoosporangia, or (2) resting spores (probably agamic); zoospores spherical or ellipsoid, uniciliate, escaping through a tube or papillary orifice; antherids and oogones appear to be wanting.—Minute parasites in the parenchyma cells of aquatic higher plants, or the slimy secretions of green algae. (In this family, which is doubtless related to the Saprolegniaceae, the structural degeneration, due to their hysterophytic habits, appears to have affected the sexual reproductive organs more than the vegetative filaments. Compare also with Ancylistaceae.)

KEY TO THE GENERA.

A. Only zoospores known,	1. *Cladochytrium.*
B. Only resting spores known,	2. *Physoderma.*

1. *Cladochytrium* Nowakowski. Vegetative filaments widely dispersed in the host, intracellular, giving rise to terminal and intercalary spherical or ellipsoid zoosporangia; resting spores unknown. —Minute parasites (of few species) living in the cells of higher plants. Zoosporangia 18μ to larger; zoospores 2 to 5μ.

2. *Physoderma* Wallroth. Vegetative filaments intracellular, penetrating the walls from cell to cell, giving rise to terminal and intercalary spheroidal or ellipsoid, thick- and brittle-walled, brown resting spores; zoosporangia unknown.—Minute parasites (of few species) living in the cells of higher plants. Resting spores 25 to 35μ by 15 to 30μ.

Family ANCYLISTACEAE

Plant a reduced, parasitic, colorless filament (sometimes a single cell, or even a naked mass of protoplasm), at first non-septate, later dividing into several cells which (1) become zoosporangia and divide into zoospores, which are mostly biciliate, or (2) develop long germinating tubes which penetrate new hosts, or (3) transform into antherids or oogones; the single egg within the oogone is fertilized by means of a tube, resulting in the production of a thick-walled zygote. (In *Diplophysa* and *Rhizomyxa* the single cell composing the whole plant may form a single zoosporangium, or by division, an antherid and an oogone.)—Minute parasites living in the cells of various aquatic plants, and the root-hairs and epidermal cells of higher plants. (In this family, which is doubtless related to the Saprolegniaceae, the structural degeneration, due to their hysterophytic habits appears to have affected the vegetative filaments more than the sexual reproductive organs. Compare with Cladochytriaceae.)

KEY TO THE GENERA.
A. Zoospores present,
    I. Plant body always with a cell wall, zoospores usually biciliate,
        a. Producing several zoosporangia, or oogones,
            1. Plant a branched filament, 1. *Lagenidium.*
            2. Plant an unbranched filament, 2. *Myzocytium.*
        b. Plant body producing but one zoosporangium or oogone, 3. *Diplophysa.*
    II. Plant body without a cell wall until the formation of reproductive cells; zoospores uniciliate, 4. *Rhizomyxa.*
B. No zoospores known, 5. *Ancylistes.*

1. *Lagenidium* Schenk. Vegetative filament at first unbranched and tubular, later with spherical, clavate, or cylindrical branches, becoming septate, the whole plant eventually consisting of reproductive cells; zoosporangia usually broad-cylindrical, straight or curved, the contents escaping by a tube into a bladdery enlargement outside of the host and there dividing internally into reniform, laterally biciliate zoospores; antherids usually cylindrical, lateral or intercalary, penetrating the oogone wall by a fertilizing tube; oogones intercalary, swollen or spheroidal, containing an undifferentiated protoplasm, which becomes condensed after fertilization into a spherical, smooth-walled zygote.—Minute parasites (of few species) in the cells of fresh-water algae, and pine pollen cells. Filaments 3 to 7.5μ; zygotes 11 to 29μ.

2. *Myzocytium* Schenk. Vegetative filaments unbranched, at first tubular, later constricted into a chain of two to many oval or ellipsoidal cells, the whole plant eventually consisting of reproductive cells; zoosporangia formed from the unmodified cells, their con-

tents escaping by a tube into a bladdery enlargement outside of the host and there dividing into reniform, laterally biciliate zoospores; antherids and oogones similar, the former penetrating the latter by a direct fertilizing tube; oogone containing undifferentiated protoplasm which becomes condensed, after fertilization, into a spherical, smooth-walled zygote.—Minute parasites (of few species) in the cells of fresh-water algae and aquatic worms. Filaments 20μ in diameter; zygotes 15 to 20μ.

3. *Diplophysa* Schroeter. Vegetative plant body consisting of but a single, spherical or ellipsoidal cell which may transform directly into a zoosporangium; zoospores ovate or spheroidal, uniciliate or biciliate, escaping singly by a tube; generation by the division of the vegetative cell into two cells, the smaller of which becomes the antherid, and eventually pierces the other—the oogone—with a fertilizing tube, the result being a thick-walled zygote.—Minute, and very much reduced parasites (of few species) in fresh-water algae and water moulds. Antherids 28 to 30μ; zygotes 68 to 78μ.

4. *Rhizomyxa* Borzi. Vegetative plant body at first a plasmodium-like mass of protoplasm, later (1) dividing directly into ovate, uniciliate zoospores, or (2) forming thin-walled resting sporangia, which eventually give rise to similar zoospores, these escaping singly through a short tube; generation by the division of the plant body into two-walled cells, the smaller of which becomes the clavate antherid, and pierces the other—the oogone—with a fertilizing tube, the result being a smaller, thick-walled zygote.—Minute, and very much reduced parasites (one species) in the hairs and epidermal cells of roots of many higher plants. Zoospores 5 to 6μ; oogones 25 to 40μ; zygotes 15 to 20μ.

5. *Ancylistes* Pfitzer. Vegetative filaments unbranched, or with short protuberances, at first tubular, later dividing into numerous cells; propagation by means of long "infection tubes" sent out by the cells of the filaments, coming in contact with and penetrating other hosts; zoospores wanting; generation by the transformation of certain cells into antherids, and others (in larger filaments) into oogones, the former penetrating the latter by a fertilizing tube, resulting in the contraction of the undifferentiated oogone protoplasm into a spherical or ellipsoid, thick-walled zygote.—Minute parasites (one species) in desmids of the genus *Arthrodia* (*Closterium* of authors). Male filaments 6μ; female, 10μ; zygotes 15 to 24μ.

Family PERONOSPORACEAE

Downy Mildews

Plants minute, without chlorophyll, mostly endophytic, and typically parasitic (rarely aquatic, and parasitic or saprophytic on animals or plants), consisting of much-branched, non-septate filaments which penetrate their hosts, and from which they send out (into the air or water) slender, more or less branched conidiophores; rhizoids not present; propagation by the formation of conidia which may give rise to laterally biciliate, usually reniform, zoospores (1) immediately (then known as zoosporangia), or (2) after falling (then known as metasporangia), or they may germinate after falling, by sending out a slender tube which grows directly into a new filament; zoospores after a period of activity, becoming spherical, motionless cells and germinating by sending out a slender tube which forms a new filament; generation by the formation of a single spherical egg in each globular oogone, which is then fertilized by the transfusion of the protoplasm of the clavate antherid (usually originating near by) through the slender fertilizing tube, resulting in the formation of a thick-walled zygote; the latter germinates directly, or by the formation of zoospores.

KEY TO THE GENERA.

A. Conidia giving rise to zoospores,
  I. Conidia formed in chains, or singly, not terminating the growth of the conidiophore,
    a. Zoosporangia, as well as metasporangia, formed, the contents being extruded before the formation of zoospores, 1. *Pythium.*
    b. Only metasporangia present, the contents escaping as zoospores,
      1. Conidia formed in chains, 2. *Albugo.*
      2. Conidia formed singly, becoming lateral by the continued growth of the conidiophore, 3. *Phytophthora.*
  II. Conidia formed singly, terminating the growth of the conidiophore,
    a. Conidiophores several times branched,
      1. Persistent; zygote free from the oogone wall. 4. *Plasmopara.*
      2. Fugacious; zygote attached throughout to the oogone wall, 5. *Sclerospora.*
    b. Conidiophores simple, terminally swollen, bearing conidia on short sterigmata, 6. *Basidiophora.*
B. Conidia germinating by a slender tube,
  I. Germinating tube arising from a terminal papilla, 7. *Bremia.*
  II. Germinating tube lateral, conidia not papillate, 8. *Peronospora.*

1. *Pythium* Pringsheim. Vegetative filaments slender (without haustoria) penetrating the cells of the host, saprophytic or parasitic on animals or plants in water, or parasitic within the tissues of land plants; conidia rounded or elliptical, forming singly or in chains on unmodified portions of the plant, of two kinds (1) zoosporangia, and (2) metasporangia, emitting their protoplasm in a mass through a short tube, and then by division forming many zoospores; oogones terminal or rarely intercalary, the smooth or rough-walled zygote free from the oogone wall, and germinating like the conidia, or by the growth of a tube into a new filament.—Species many.

2. *Albugo* J. F. Gray (*Cystopus* Leville). Vegetative filaments growing parasitically in the intercellular spaces of their hosts, and sending short, terminally swollen haustoria into the adjacent cells; conidiophores clavate, grouped in large masses beneath the epidermis, which they rupture, bearing terminal chains of conidia, which germinate, after falling, by the internal formation of zoospores which escape through a terminal orifice; oogones mostly terminal, rarely intercalary, the rough-walled zygote free from the oogone wall, germinating by the internal formation of zoospores.—Species many, in dicotyledons.

3. *Phytophthora* DeBary. Vegetative filaments growing parasitically in the cells and intercellular spaces of their hosts, and sending their slender, sparingly branched conidiophores out into the air through the stomata, or directly through the epidermal cells; conidia ovate or ellipsoidal, at first solitary and terminal, becoming lateral by the continued growth of the conidiophore, germinating after falling, by the internal formation of zoospores, which escape through the terminal papillary orifice; oogones mostly terminal, the smooth zygote free from the oogone wall, and germinating by a tube terminated by a conidium.—Species few, in various dicotyledons, and the seedlings of conifers.

4. *Plasmopara* Schroeter. Vegetative filaments growing parasitically in the intercellular spaces of their hosts, bearing small haustoria, and sending into the air through the stomata numerous persistent branched conidiophores, which are monopodial, except for the ultimate branchlets; conidia spherical to ellipsoidal, single, terminating the growth of the branches, germinating by the internal formation of zoospores, or by the extrusion of the protoplasm, which becomes a walled cell, later growing by tubular prolongation into

a new filament; oogones usually terminal, the smooth zygote free from the oogone wall, and germinating by a tube terminated by a conidiophore.—Species many, in dicotyledons.

5. *Sclerospora* Schroeter. Vegetative filaments growing parasitically in the intercellular spaces of their hosts, bearing small haustoria, and sending into the air through the stomata the stout, fugacious conidiophores, which are monopodially branched, except for the ultimate branchlets; conidia ellipsoidal, single on basally-swollen ultimate branchlets, whose growth they terminate, germinating after falling, by the internal formation of zoospores; oogones terminal, entirely filled by the smooth, spherical zygote, whose walls are grown fast to the thick, irregular oogone wall; germination unknown.—Species two, in grasses and joint rushes.

6. *Basidiophora* Roze & Cornu. Vegetative filaments growing parasitically in the intercellular spaces of their hosts, bearing small haustoria, and sending into the air through the stomata the unbranched, capitately swollen conidiophores, which bear at their summits several short projections (sterigmata) each terminating in a single, spherical or ellipsoidal conidium; conidia germinating after falling by the internal formation of zoospores, which escape through the terminal capillary orifice; oogones terminal, the irregularly wrinkled zygote free from the oogone wall; germination unknown.—Species one, in Compositae.

7. *Bremia* Regel. Vegetative filaments growing parasitically in the intercellular spaces of their hosts, bearing short or clavate unbranched haustoria, and sending into the air through the stomata the repeatedly dichotomous conidiophores whose ultimate branchlets bear terminal, shallow cups, each with several short marginal sterigmata, bearing as many ellipsoidal conidia; conidia germinating by the protrusion of a slender tube through the terminal papilla; oogones terminal, thin-walled, completely filled by the smooth, thin-walled zygote; germination unknown.—Species one, in Compositae.

8. *Peronospora* Corda. Vegetative filaments growing parasitically in the intercellular spaces of their hosts, bearing large, branched (rarely small) haustoria, and sending into the air through the stomata the repeatedly dichotomous conidiophores whose ultimate branches are simple; conidia ellipsoidal, to ovate, without a terminal papilla, germinating laterally by a slender tube; oogones usually terminal, larger than the zygote, whose walls are irregularly thickened;

germination by means of a slender tube.—Species very many, mostly in dicotyledons.

Family MUCORACEAE

Black Moulds

Plants saprophytic or parasitic, consisting of much branched, non-septate vegetative filaments, which bear the more or less erect sporophores, the former more or less rhizoid-like and penetrating the substratum, the latter aerial (in one genus aquatic), cylindrical or swollen, simple or branched, and often bearing rhizoids below; propagation (1) by the internal division of the end cells of the aerial branches (sporophores) into internal spores, (*a*) in single enlarged end cells (sporangia) each producing few to many irregularly arranged spores (zoospores in one genus), and (*b*) in several or many narrow (or spherical) end cells, each producing one, or more often, few to many spores in a single row, these set free as a row of spores ("conidia") by the early dissolution or fracture of the sporangial wall (sometimes apparently formed by abstriction); (2) by the formation of thick-walled resting cells (chlamydospores) in the vegetative filaments; generation by the coming together of two usually lateral branches, mostly upon vegetative filaments, the formation of a septum near the end of each, the absorption of the wall between the united cells, and the fusion of their contents into a zygote, which eventually becomes thick-walled.

KEY TO THE GENERA.

- A. Plants aquatic, 1. *Zygochytrium.*
- B. Plants not aquatic, living saprophytically or parasitically in the air,
  - I. Sporophore or its branches with a single, terminal, enlarged, spheroidal, many-spored sporangium,
    - a. Sporangium with a columella,
      - 1. Sporangium-wall little, if at all, thickened,
        - *a.* Plant without stolons, sporophores single,
          - 1. Sporophore simple, at least not dichotomously branched.
            - *α.* Aerial filaments smooth-walled,
              - §. Glossy, dull, gray or brown, 2. *Mucor.*
              - §§. Metallic green or olive, 3. *Phycomyces.*
            - *β.* Aerial filaments thorny, 4. *Spinellus.*
          - 2. Sporophores dichotomously branched, 5. *Syzygites.*
        - *b.* Plant with stolons bearing rhizoids and tufted sporophores at the nodes, 6. *Ascophora.*

2. Sporangium-wall thickened above, thin below, 7. *Hydrogera.*
b. Sporangium without a columella, 8. *Mortierella.*
II. Sporophore with a single terminal, enlarged, many-spored sporangium, and few to many lateral, smaller, few-spored sporangia, 9. *Thamnidium.*
III. Sporophore much-branched, with many small, spherical, one-spored (conidia-like) sporangia on short lateral branches, 10. *Chaetocladium.*
IV. Sporophore much-branched, bearing terminal clusters of narrow, few-spored sporangia,
a. All of the ramuli bearing sporangia, 11. *Piptocephalis.*
b. Some of the ramuli circinate and sterile, 12. *Dispira.*
V. Sporophore unbranched, bearing upon the terminally enlarged apex many narrow, radiating sporangia (resembling conidia chains), 13. *Syncephalis.*

1. *Zygochytrium* Sorokin. Plants aquatic, saprophytic, the pale yellow filaments erect and irregularly branched, attached to the substratum by short, irregular rhizoids; sporangia solitary on the ends of the branches, without columella, opening by a circular lid; zoospores spherical, uniciliate; zygote spherical, thick-walled, red, formed by the union of lateral branches from the erect filaments.—One species, on dead flies, gnats, wasps, etc., in water.

2. *Mucor* Linne. Plants saprophytic, the vegetative filaments smooth-walled, abundant, and penetrating the substratum, rhizoid-like and tapering at the extremities, at first white, later dusky or blackish; sporophores erect, simple or monopodially or sympodially branched; sporangia many-spored, spherical or pyriform, thin-walled, mostly dark-colored, with a large columella; spores spherical or elliptical, mostly dark-colored, escaping by the irregular rupture of the sporangium wall; zygotes formed in the vegetative filaments (rarely found).—Species many, on organic matter.

3. *Phycomyces* Kunze. Plants saprophytic, the vegetative filaments smooth-walled, abundant, and penetrating the substratum, rhizoid-like and tapering at the extremities; sporophores erect, simple, metallic-green or olive; sporangia large, many-spored, spherical, thin-walled, brownish, with a large, pyriform columella; spores ellipsoid, yellowish, escaping by the dissolution of the sporangium wall; zygotes formed in the vegetative filaments, the adjacent cells with dichotomously branched, dark-brown outgrowths.—Two species on oily or decaying organic matter.

4. *Spinellus* Van Tieghem. Plants parasitic, composed of delicate filaments penetrating the host, and brown, thorny, irregularly-branched, aerial filaments which bear the sporangia and sexual cells; sporophores simple; sporangia large, spherical, with a globular columella; spores fusiform to spherical, escaping by the dissolution of the sporangium wall; zygote barrel-shaped, smooth, formed in the aerial filaments.—Species few, on agarics.

5. *Syzygites* Ehrenberg. Plants saprophytic, composed of delicate filaments penetrating the substratum, and dichotomously branched aerial filaments which bear the sporangia and sexual cells; sporophores dichotomously branched, eventually septated; sporangia spherical, with a hemispherical columella; spores round or ellipsoid, escaping by the early dissolution of the sporangium wall; zygotes spheroidal and smooth, formed on specially developed dichotomously branching aerial filaments.—One species on decaying agarics and other large fungi.

6. *Ascophora* Tode. Plants saprophytic, composed of delicate filaments penetrating the substratum, and dichotomously branched aerial filaments which send out stolons in all directions, these bearing rhizoids and sporophores at the nodes; sporophores non-septate, simple, tufted, swollen just below the nearly spherical sporangium; columella hemispherical, collapsing and becoming umbrella-shaped when old; spores spherical or somewhat angled, escaping by the early disappearance of the sporangium wall; zygotes spherical or nearly so, with a thick, warty, dark-brown wall, formed in the mass of vegetative filaments in or on the substratum.—Species few, on organic matter and decaying substances.

7. *Hydrogera* Wiggers (*Pilobolus* Tode). Plants saprophytic, composed of much-branched filaments with tapering, rhizoid-like ramuli, penetrating the substratum, without stolons, and producing erect, simple, terminally enlarged sporophores, which arise from swollen portions of the vegetative filaments; sporangium terminal, hemispherical, with its wall thickened, black, and cuticularized above, and thin and evanescent below; columella small, conical; spores spherical or ellipsoid; zygotes spherical or barrel-shaped, formed in the mass of vegetative filaments.—Species few, on excrement.

8. *Mortierella* Coemans. Plants saprophytic, composed of very slender and weak, branching filaments penetrating and running over

the substratum, spreading by many stolon-like anastomosing branches, more or less septate when old; sporophores erect, single or tufted, simple or branched, mostly colorless, sometimes with rhizoids below; sporangia terminal, spherical, thin-walled, without columella; spores mostly spherical or elliptical, colorless, variable in size, escaping by the early rupture of the sporangium wall; zygote formed in the mass of vegetative filaments, spherical, surrounded by the dense growth of filaments arising from the adjacent cells.—Species many, on excrement and other decaying matter.

9. *Thamnidium* Link. Plants saprophytic, composed of much-branched, colorless filaments penetrating the substratum, without stolons, and producing erect, branched sporophores; sporangia of two kinds, (1) larger, single, terminal, many-spored, with a columella, (2) smaller, clustered, lateral, few-spored, without a columella; spores alike, spherical or ellipsoid, escaping by the disappearance of the sporangium wall; zygotes spherical or barrel-shaped, thick-walled, dark brown or black, formed in the mass of vegetative filaments.—Species few, on excrement and other decaying matter.

10. *Chaetocladium* Fresenius. Plants parasitic or saprophytic, composed of slender, colorless, much-branched filaments, attached to their hosts by clusters of short, thick rhizoids (haustoria); sporophores rarely erect, mostly creeping, at length septate, repeatedly branched, each branch ending in a long-pointed sterile thread; conidia-like sporangia spherical, single (not in chains) approximated in botryoid clusters, on short lateral branches; zygotes formed on the vegetative filaments, spherical, naked.—Species few, on other Mucoraceae.

11. *Piptocephalis* DeBary. Plants parasitic, consisting of slender, branching filaments, producing here and there dense clusters of rhizoids which penetrate their hosts, sometimes producing stolons; sporophores erect, dichotomously branched, septate and brownish with age, the ultimate ramuli not terminally enlarged; " conidia " cylindrical or spherical, in radial chains clustered on the ends of the ramuli; zygotes formed on the vegetative filaments, spherical, naked. —Species few, on other Mucoraceae.

12. *Dispira* Van Tieghem. Plants parasitic, consisting of slender branching filaments attached to their hosts by large rhizoids; sporophores erect, septate, colorless, much branched, some of the ulti-

mate ramuli sterile and circinate, the others terminally swollen and papillate, bearing numerous short, 1-septate sterigmata, each developing terminal clusters of "conidia"-chains of two ovoid hyaline cells; zygote spherical, brownish, formed by the union of two contiguous cells in a filament (in the single known case the filament attaches itself to its host, cuts off a swollen cell next to the host, this soon emptying its contents into the adjacent cell, which then becomes a zygote).—Species few, parasitic on other Mucoraceae.

13. *Syncephalis* Van Tieghem and Le Monnier. Plants parasitic (rarely saprophytic), consisting of very slender, branching and anastomosing filaments, producing numerous clusters of rhizoids which penetrate their hosts; sporophores stout, erect, mostly unbranched, enlarged above, and bearing a cluster of forked rhizoids below; " conidia " cylindrical to fusiform, in many radiating chains clustered on the enlarged summit of the sporophore; zygote spherical, naked, formed on the vegetative filaments.—Species many, on other Mucoraceae (occasionally on excrement).

Family ENTOMOPHTHORACEAE

Insect Fungi

Plants parasitic in the bodies of insects (rarely endophytic or saprophytic), consisting of much-branched, tubular, mostly endozoic, filaments, eventually septate, and often separating into distinct segments, sometimes bearing rhizoids which attach the host to the substratum; propagation by the abstriction of single conidia from the ends of short, aerial filaments and by the asexual formation of resting spores in the vegetative filaments; generation (mostly within the host) by the union of two approximate or adjacent cells or segments, and the development of a thick-walled zygote.

KEY TO THE GENERA.

A. Parasites of insects,	1. *Entomophthora.*
B. Parasites of plants,	
I. In the cells of fern prothallia,	2. *Completoria.*
II. On higher fungi,	3. *Conidiobolus.*
C. Saprophytes on excrement,	4. *Basidiobolus.*

1. *Entomophthora* Fresenius. Vegetative filaments growing mostly in the soft interior tissues of insects, in some cases growing

externally also, branched, commonly separated into segments, sometimes bearing rhizoids which attach the host to the substratum; conidiophores simple, or more or less branched, penetrating the body-wall of the host and forming upon each a single, terminal, spherical or fusiform conidium; resting spores formed asexually in the vegetative filaments, or by the union of the protoplasm of two cells.—Species many (including, also, those of *Empusa, Lamia,* and *Tarichium* of some authors), parasitic on flies, mosquitoes, aphids, locusts, caterpillars, and many other insects.

2. *Completoria* Lohde. Vegetative filaments growing in the cells of fern prothallia, at first tubular, later with many irregular branches; conidiophores simple, penetrating the cell wall, each forming a single ovoid conidium; asexual resting spores produced by the contraction of the protoplasm of a vegetative cell, and the formation of a thick wall.—One species, not yet reported for North America.

3. *Conidiobolus* Brefeld. Vegetative filaments growing parasitically on higher fungi (rarely saprophytic), well developed, much branched, more or less septate, and eventually separating into segments; conidiophores erect, simple, clavate, each bearing a single, ovoid conidium; zygotes thick-walled, spherical, formed by the union of two segments of the vegetative filaments.—Species two, not yet reported for North America.

4. *Basidiobolus* Eidam. Vegetative filaments growing saprophytically on excrement, well developed, much branched, at first continuous, later septate; conidiophores erect, clavate, each bearing a single terminal, ovoid conidium; zygotes thick-walled, spherical, formed by the union of two adjacent filaments.—Species two, on the excrement of frogs and lizards.

NOTES ON THE SEXUAL ORGANS OF SAPROLEGNIACEAE, PERONOSPORACEAE, MUCORACEAE, AND ENTOMOPHTHORACEAE

1. Typical antherids and oogones occur in the aquatic holophytic plants constituting the family Vaucheriaceae.

2. The antherids and oogones of the Saprolegniaceae are so modified on account of their parasitic habit, as to result in the suppression of the antherozoids, and the transfer of the contents of the antherid to the oogone directly. The same has occurred in the Peronospora-

ceae, here perhaps in part due to the fact that fertilization takes place in the air (not in the water).

3. The sexual organs of the Mucoraceae are of the type of the Saprolegniaceae, as modified in the non-aquatic Peronosporaceae, and like them they are lateral diverticula each of which cuts off an end cell (antherid and oogone).

4. The sexual organs of the Mucoraceae are in process of extinction; in the ontogeny of each plant they never fully develop, and are no more than mere rudiments (anlagen); phylogenetically they are not rudiments but vestiges.

5. These physically under-developed and but little differentiated sexual organs of the Mucoraceae conjugate prematurely, before the oogone is ready for fertilization, and the act is merely a fusion of the nearly undifferentiated gametes. At the instant of conjugation there is no oogone proper in which a zygote can form, but this premature conjugation stimulates the growth of the egg cavity (oogone, zygogone).

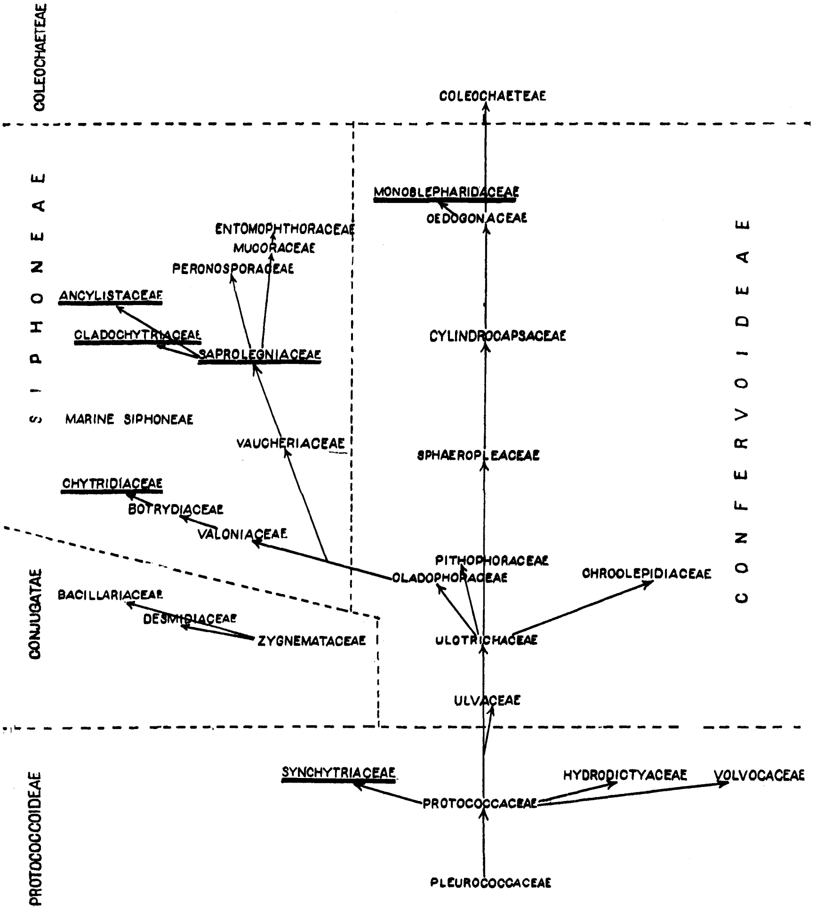
6. The sexual organs of the Entomophthoraceae are similar to those of Mucoraceae, and are likewise in process of extinction.

EXPLANATION OF PLATE II

Chart Showing the Relationship of the Phycomycetes

The names of the orders are printed in vertical lines and the families in horizontal. Those of the fungi are underlined.

PLATE II


COLEOCHAETEAE
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MONOBLEPHARIDACEAE
OEDOGONACEAE
ENTOMOPHTHORACEAE
MUCORACEAE
PERONOSPORACEAE
ANCYLISTACEAE
CLADOCHYTRIACEAE
SAPROLEGNIACEAE
CYLINDROCAPSACEAE
CONFERVOIDEAE
MARINE SIPHONEAE
VAUCHERIACEAE
SPHAEROPLEACEAE
CHYTRIDIACEAE
BOTRYDIACEAE
VALONIACEAE
PITHOPHORACEAE
CLADOPHORACEAE
CHROOLEPIDIACEAE
CONJUGATAE
BACILLARIACEAE
DESMIDIACEAE
ZYGNEMATACEAE
ULOTRICHACEAE
ULVACEAE
PROTOCOCCOIDEAE
SYNCHYTRIACEAE
HYDRODICTYACEAE
VOLVOCACEAE
PROTOCOCCACEAE
PLEUROCOCCACEAE